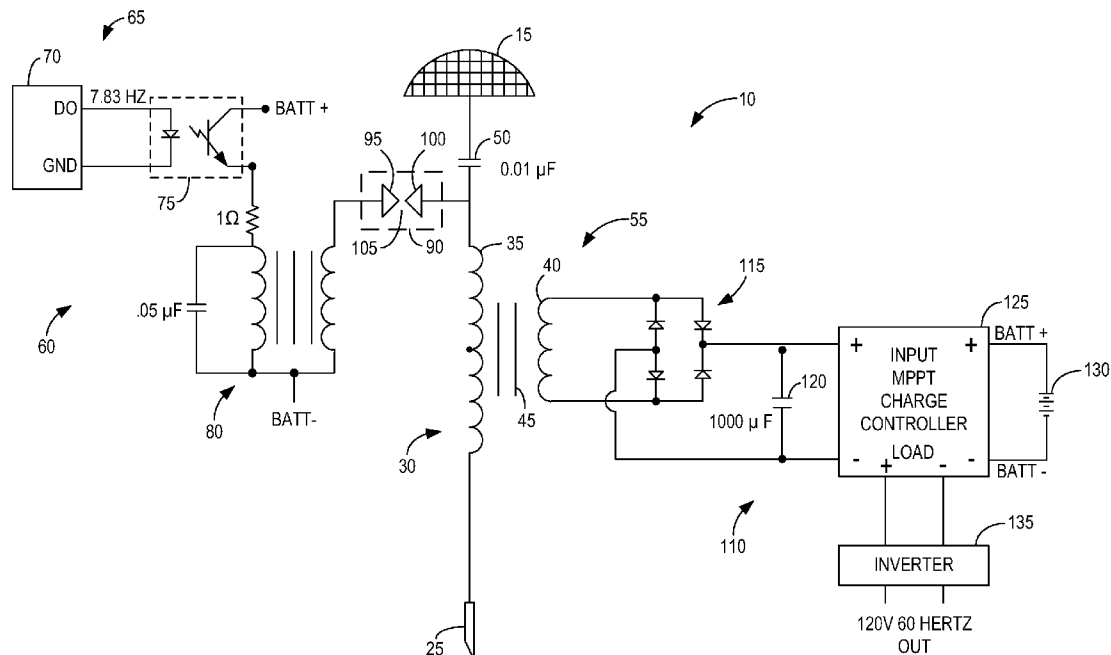




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(19) **United States**(12) **Patent Application Publication**
Dinwiddie et al.(10) **Pub. No.: US 2015/0102675 A1**(43) **Pub. Date: Apr. 16, 2015**(54) **POWER RECEIVER FOR EXTRACTING
POWER FROM ELECTRIC FIELD ENERGY
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L. Wright**, Suwanee, GA (US); **David
R. Ames**, Johns Creek, GA (US)(21) Appl. No.: **14/509,772**(22) Filed: **Oct. 8, 2014****Related U.S. Application Data**(60) Provisional application No. 61/889,894, filed on Oct.
11, 2013.**Publication Classification**(51) **Int. Cl.**
H02J 4/00 (2006.01)(52) **U.S. Cl.**
CPC **H02J 4/00** (2013.01)(57) **ABSTRACT**

A resonant transformer connected between a ground terminal and elevated terminal draws current from the earth's electric field through a primary winding of the transformer. An impulse generator applies a high voltage impulse to the primary winding of the resonant transformer to cause current to flow from the ground terminal through the primary winding. The flow of current through the primary winding of the resonant transformer induces a current in the secondary winding, which may be converted and filtered to a usable form, e.g. 60 Hz AC or DC.



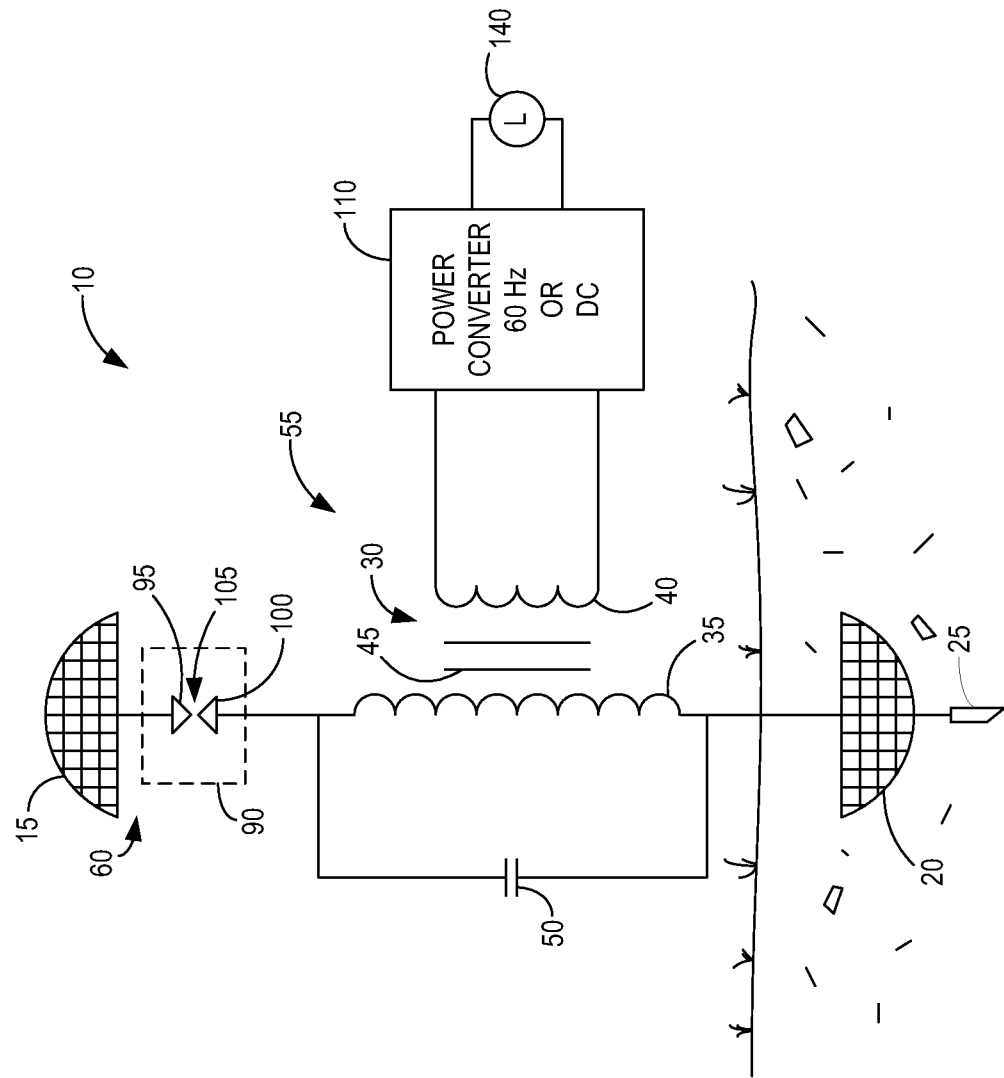


FIG 1

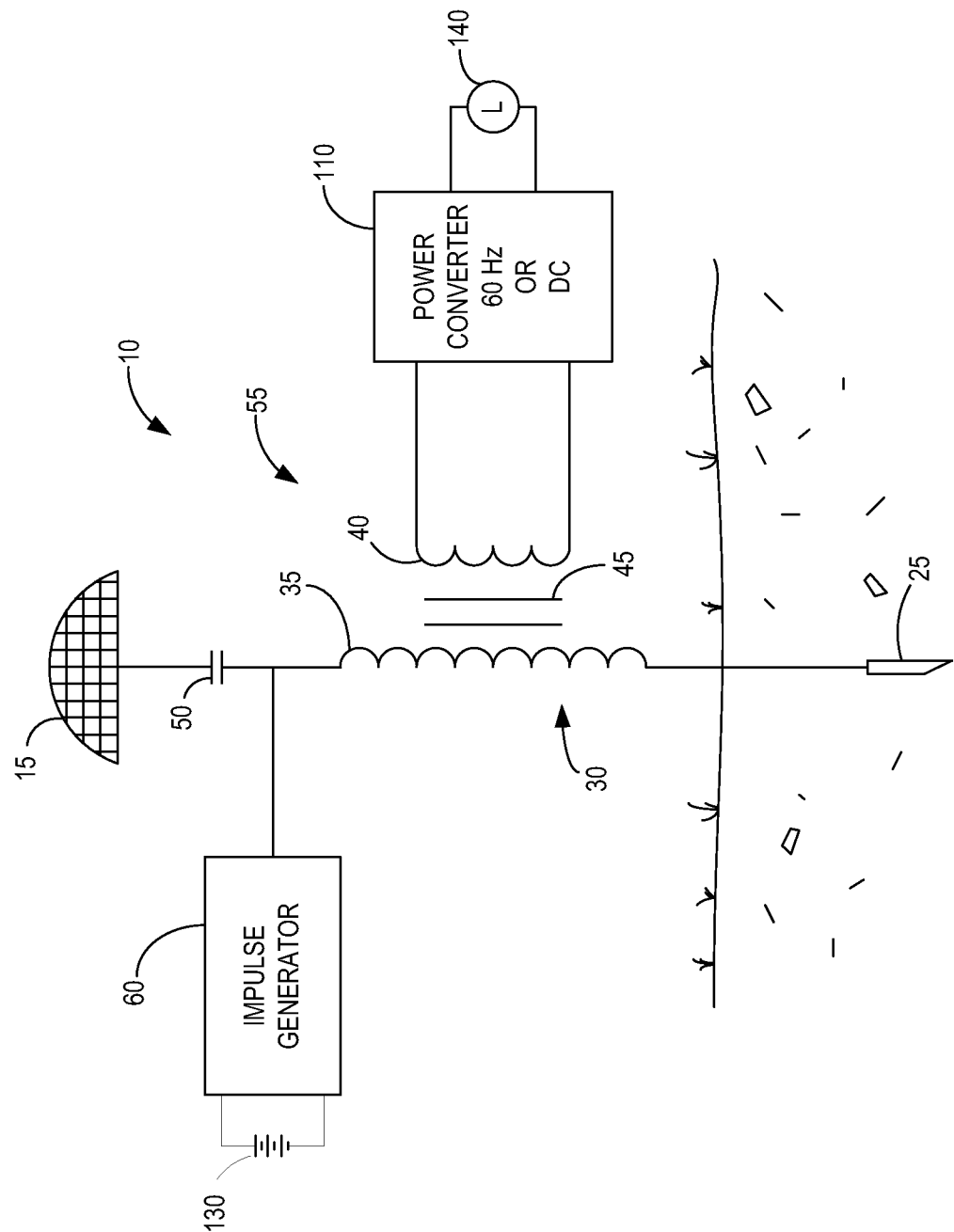


FIG 2

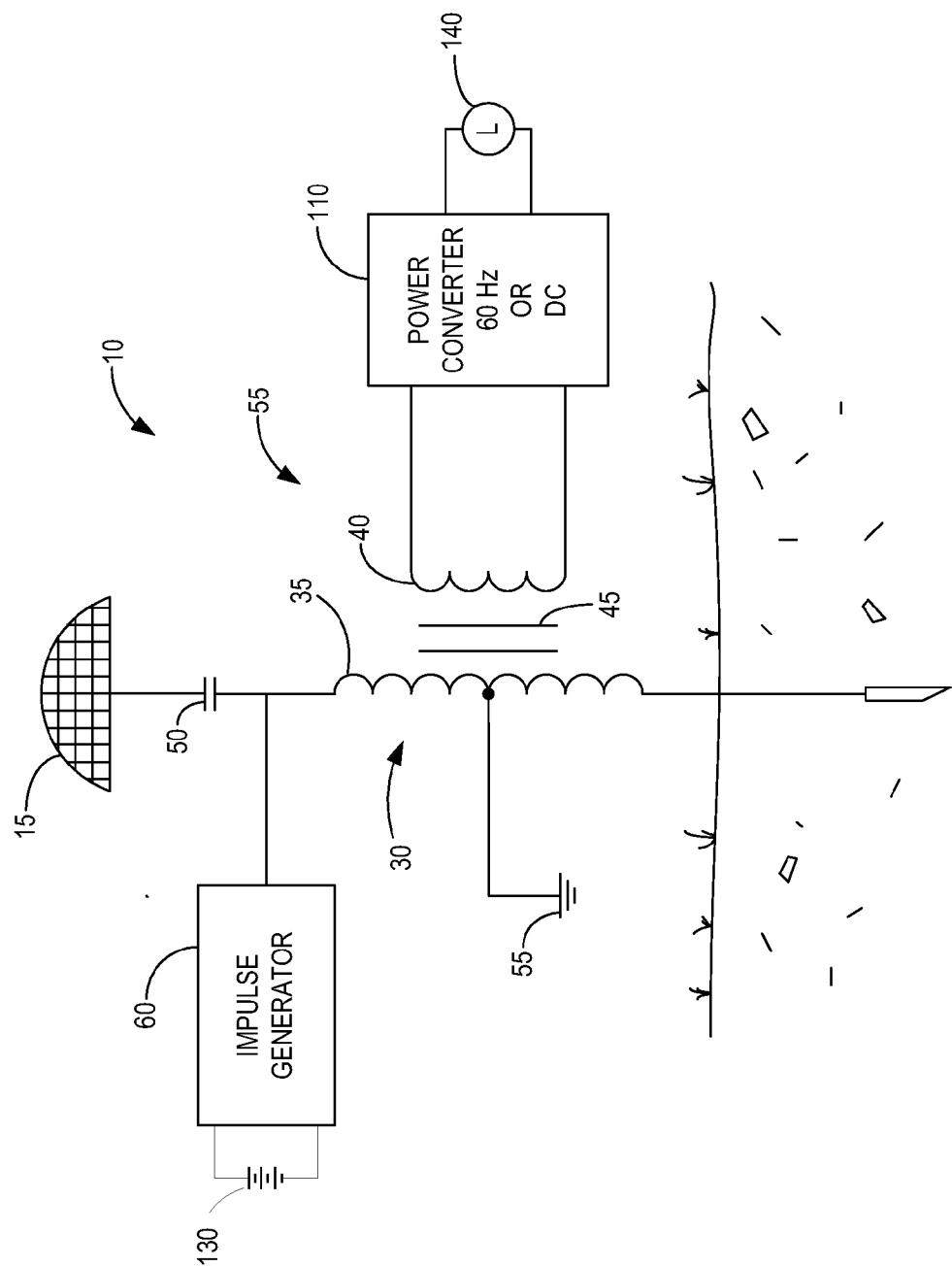


FIG 3

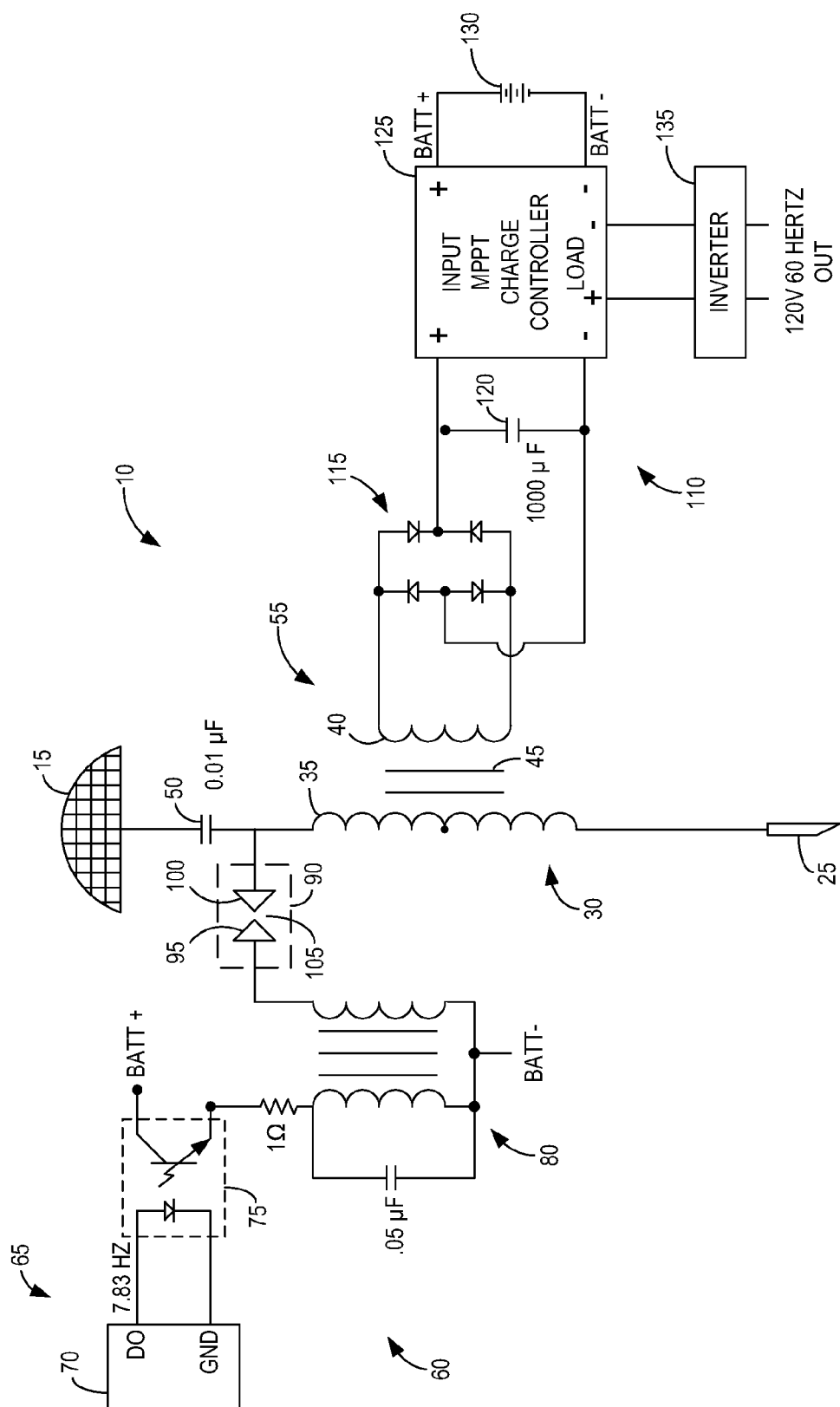


FIG 4

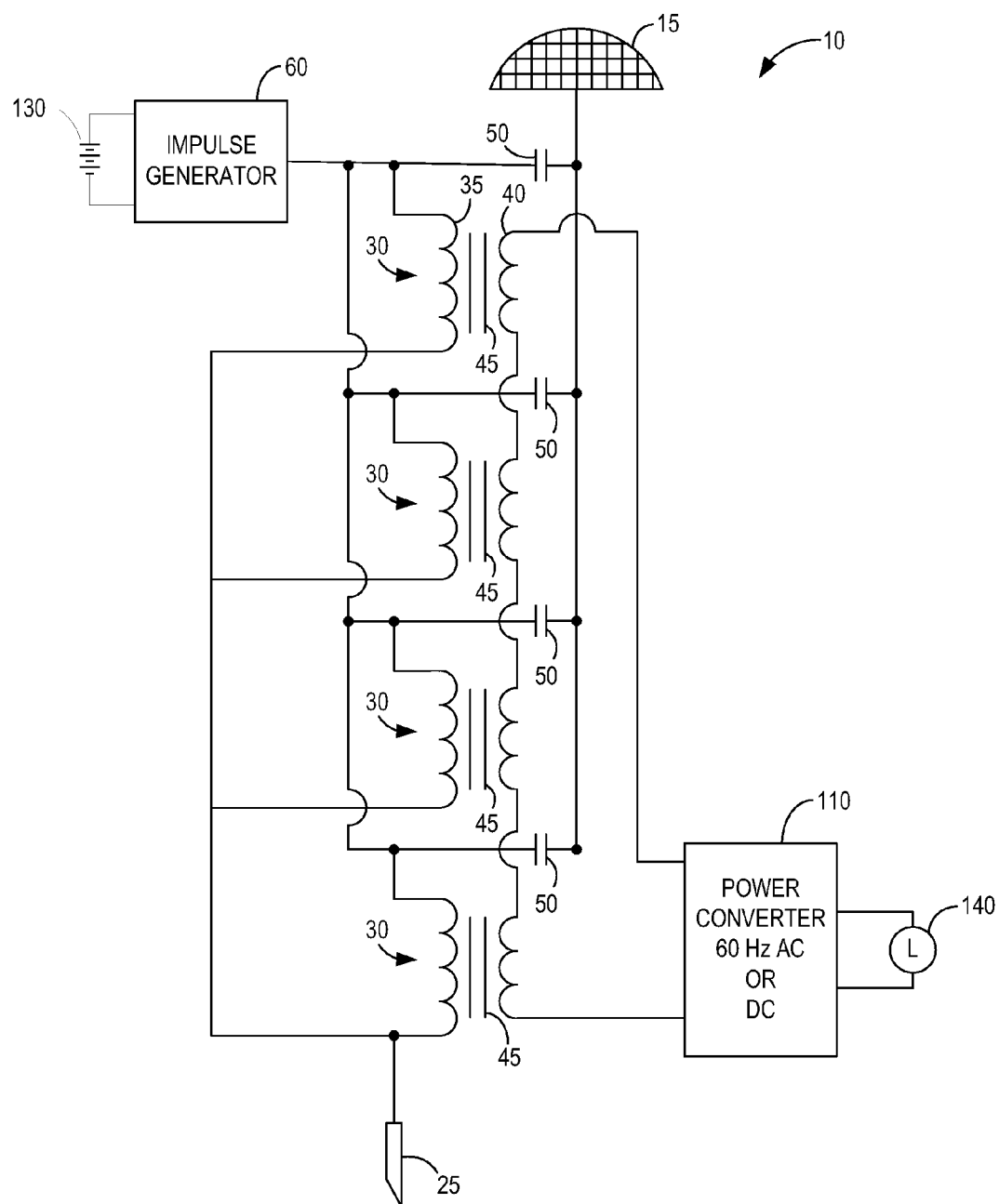


FIG 5

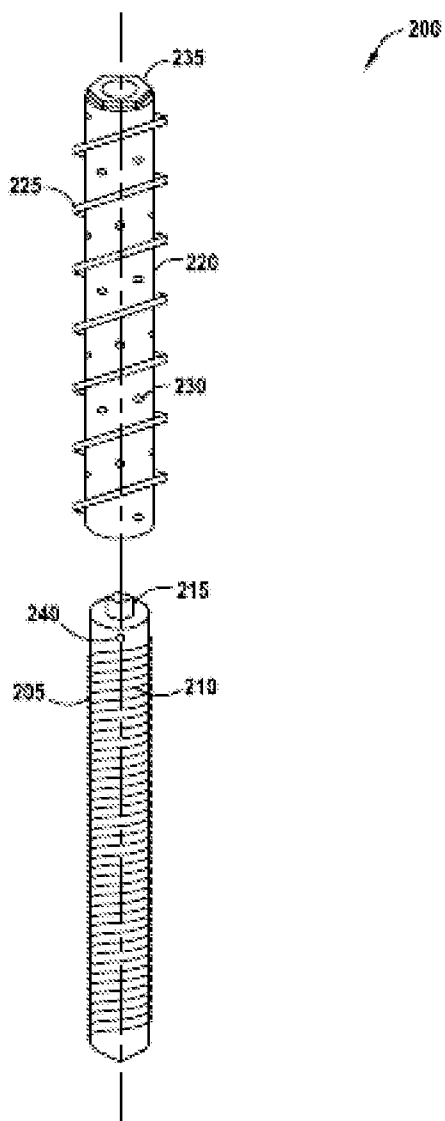


FIG 6A

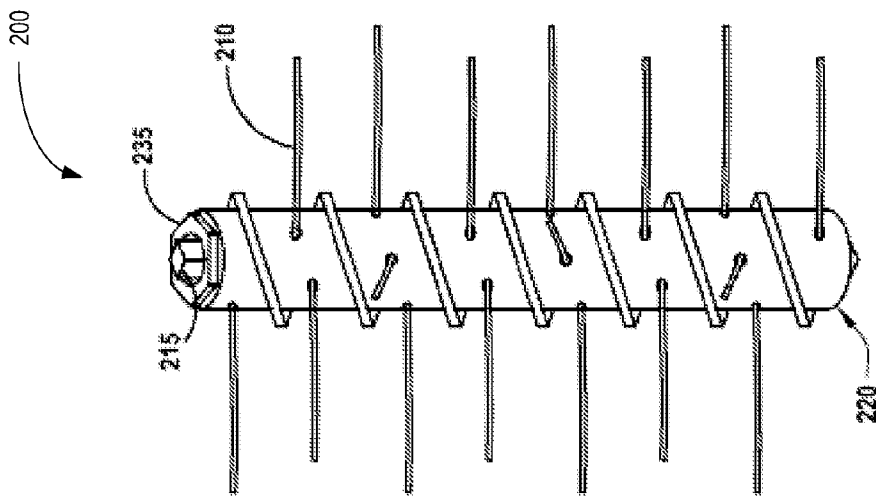


FIG 6C

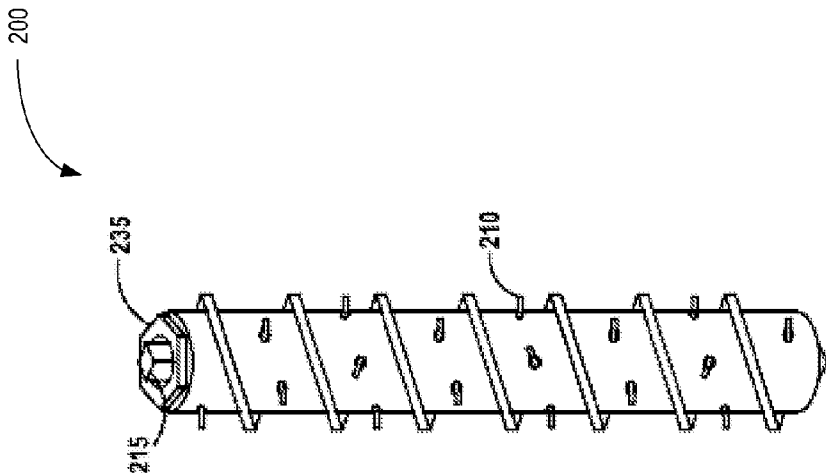


FIG 6B

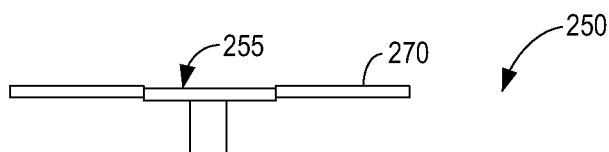


FIG 7A

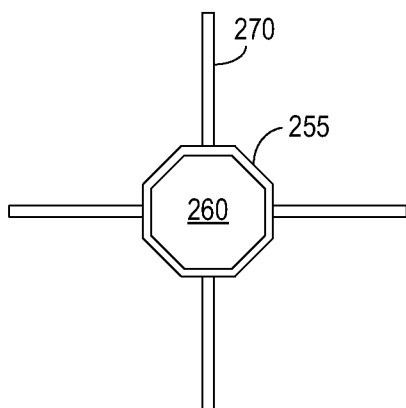


FIG 7B

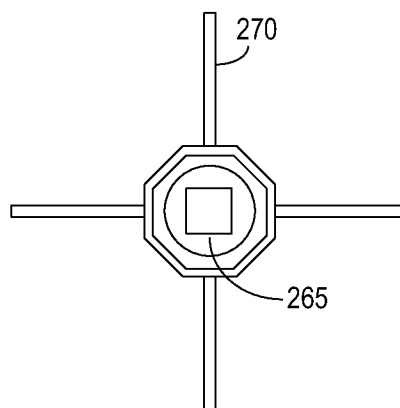


FIG 7C

POWER RECEIVER FOR EXTRACTING POWER FROM ELECTRIC FIELD ENERGY IN THE EARTH

[0001] This application claims the benefit of U.S. Provisional Application No. 61/889,894, filed 11 Oct. 2013, the disclosure of which is incorporated herein by reference in its entirety.

TECHNICAL FIELD

[0002] The present invention relates generally to renewable energy, and more particularly to methods and apparatus for extracting energy from subsurface electrical fields beneath the earth's surface.

BACKGROUND

[0003] The earth and the ionosphere cavity may be viewed as a global electric circuit. Electrical currents are constantly flowing within the earth and its atmosphere. Within the earth, the majority of the earth's energy is carried by extremely low frequency (ELF) and ultralow frequency (ULF) waves in the 0-200 Hz frequency range. The earth's rotating magnetic field and positive lightning are two energy sources that sustain the ELF/ULF waves within the earth and the atmosphere.

[0004] A great deal of research has been devoted to studying the electric field present in the earth's ionosphere cavity. Joseph M. Crawley, the "Fair Weather Atmosphere as a Power Source", Proceedings ESA Annual Meeting on Electrostatics 2011; O. Jefimenko, "Operation of Electric Motors from Atmospheric Electric Field," American Journal of Physics, Vol. 39, Pgs. 776-779, 1971; M. L. Breuer, "Usability of Tapping Atmospheric Charge as a Power Source," Renewable Energy, Vol. 28, Pgs. 1121-1127, 2003. Numerous attempts have been made in the past to extract electrical energy from the earth's atmosphere. For example, U.S. Pat. No. 1,540,998 to Plauson describes a system for converting atmospheric electrical energy into usable power. These past attempts have been successful in producing only small amounts of power from the electrical field in the earth's ionosphere cavity. The modest success of these experiments compared to results from other renewable energy sources, such as solar and wind, has tempered further research and prevented widespread use of the electric field in the ionosphere cavity as an energy source.

SUMMARY

[0005] The present invention relates to a power receiver for extracting power from electric fields beneath the earth's surface. In embodiments of the present disclosure, a resonant transformer connected to a ground terminal draws current from the earth's electric field through the primary winding of the transformer. Current flow through the resonant transformer is induced by applying a high voltage impulse to the primary winding. The flow of current through the primary winding of the resonant transformer induces a current in the secondary winding, which may be converted and filtered to a usable form, e.g. 60 Hz AC or DC.

[0006] In some embodiments of the power receiver, the resonant frequency of the resonant transformers is below 200 Hz.

[0007] In some embodiments of the power receiver, the resonant transformer comprises a ferro-resonant transformer.

[0008] In some embodiments, the power receiver further comprises an elevated terminal.

[0009] In some embodiments of the power receiver, the primary winding of the resonant transformer is connected between the ground terminal and elevated terminal.

[0010] In some embodiments of the power receiver, the elevated terminal comprises an upper capacitive plate coupled to the earth's ionosphere cavity.

[0011] In some embodiments of the power receiver, the impulse generator comprises the upper capacitive plate and a spark gap connected between the upper capacitive plate and the primary winding of the resonant transformer. The spark gap comprises a pair of electrodes separated by a gap and configured to generate a spark when a voltage difference between the electrodes reaches a predetermined level.

[0012] In some embodiments of the power receiver, the impulse generator comprises a pulse generator for generating low voltage pulses, a step-up transformer for converting the low voltage pulses provided by the pulse generator to high voltage impulses, and a spark gap connected between the step-up transformer and the primary winding of the resonant transformer to generate a spark responsive to the high voltage impulses from the step-up transformer.

[0013] In some embodiments of the power receiver, the impulse generator comprises a pulse generator for generating low voltage pulses, and a step-up transformer connected to the primary winding of the resonant transformer for converting the low voltage pulses provided by the pulse generator to high voltage impulses.

[0014] In some embodiments of the power receiver, the impulse generator comprises a solid state spark generator.

[0015] In some embodiments of the power receiver, the resonant transformer includes a capacitor connected in parallel with the primary winding.

[0016] In some embodiments of the power receiver, the resonant transformer includes a capacitor connected in series with the primary winding between the impulse generator and the elevated terminal.

[0017] In some embodiments, the power receiver comprises multiple resonant transformers having primary windings connected in parallel between the ground terminal and the elevated terminal.

[0018] In some embodiments of the power receiver, the resonant transformers have different resonant frequencies.

[0019] In some embodiments of the power receiver, the resonant frequencies of the resonant transformers are all below 200 Hz.

[0020] In some embodiments of the power receiver, the resonant frequencies of the resonant transformers are matched to respective Schumann resonances.

[0021] Another embodiment of the power receiver comprises a resonant circuit connected to a ground terminal disposed below the surface of the earth, an impulse generator for generating and applying a high voltage electrical impulse to the resonant circuit to induce current flow from the ground terminal through the resonant circuit, and a power conversion circuit connected to the resonant circuit to convert electrical current flowing through the resonant circuit to a desired form. The resonant circuit has a resonant frequency below 200 Hertz.

[0022] In some embodiments of the power receiver, the resonant circuit comprises a resonant transformer having a primary winding, a secondary winding, and resonant capacitor connected in series with the primary winding.

[0023] In some embodiments of the power receiver, the resonant circuit comprises multiple resonant transformers having primary windings connected in parallel to the ground terminal.

[0024] In some embodiments of the power receiver, the resonant transformers have different resonant frequencies.

[0025] In some embodiments of the power receiver, the resonant frequencies of the resonant transformers are all below 200 Hz.

[0026] In some embodiments of the power receiver, the resonant frequencies of the resonant transformers are matched to respective Schumann resonances.

[0027] Other embodiments of the disclosure comprise a ground terminal for a power receiver. In one embodiment, the ground terminal comprises a ground shaft configured for insertion beneath the surface of the earth, a hollow cylinder surrounding the ground shaft and having a plurality of openings, and a plurality of ground wires connected at one end to the ground shaft. The ground wires are wound around the ground shaft and have free ends protruding through respective openings in the hollow shaft so that rotation of the ground shaft relative to the hollow cylinder causes the ground wires to extend radially into the earth.

[0028] Other embodiments of the disclosure comprise methods of extracting power from the earth. In one embodiment, the method comprises applying a high voltage impulse to resonant circuit coupled to a ground terminal disposed beneath the surface of the earth to initiate resonance in the resonant circuit and induce the flow of current from the ground terminal to the resonant circuit, and converting the current flowing from the ground terminal into the resonant circuit into a useful form.

[0029] In some embodiments of the method, the resonant circuit comprises a resonant transformer including a primary winding coupled to the ground terminal and a second winding coupled to a power converter, and applying a high voltage impulse to resonant circuit comprises applying a high voltage impulse to the primary winding of the resonant transformer.

[0030] In some embodiments of the method, applying a high voltage impulse to the primary winding of the resonant transformer comprises applying an impulse in the range to 10,000 to 40,000 volts to primary winding of the transformer.

BRIEF DESCRIPTION OF THE DRAWINGS

[0031] FIG. 1 illustrates a first exemplary embodiment of a power receiver.

[0032] FIG. 2 illustrates a second exemplary embodiment of a power receiver.

[0033] FIG. 3 illustrates a third exemplary embodiment of a power receiver.

[0034] FIG. 4 illustrates a fourth exemplary embodiment of a power receiver.

[0035] FIG. 5 illustrates a fifth exemplary embodiment of a power receiver.

[0036] FIG. 6A is an exploded perspective view of an exemplary ground antenna array for the power receiver.

[0037] FIG. 6B is a perspective view of an assembled ground antenna array before being deployed.

[0038] FIG. 6C is a perspective view of an assembled ground antenna array after being deployed.

[0039] FIG. 7A is a side view of an insertion tool for installing the ground antenna array.

[0040] FIG. 7B is a top view of the insertion tool for installing the ground antenna array.

[0041] FIG. 7C is a bottom view of the insertion tool for installing the ground antenna array.

DETAILED DESCRIPTION

[0042] Referring now to the drawings, a power receiver for extracting energy from the earth's electric field are illustrated and indicated generally by the numeral 10. Various embodiments of the power receiver 10 are described and similar reference numbers are used throughout the description to indicate similar components.

[0043] The power receiver 10 converts energy in the ELF/ULF waves to useful form, e.g. 60 Hz AC or DC. The power receiver 10 is essentially a resonance circuit that resonates at the natural resonance frequencies in the earth's electric field. These resonance frequencies, known as Schumann resonance frequencies, occur at 7.83 Hz, 14.3 Hz, 20.8 Hz, 27.3 Hz, and 33.8 Hz. A high voltage impulse initiates resonance within the power receiver 10. In the resonant mode, the impedance of the power receiver 10 is reduced to near zero thus inducing ground currents to flow into the power receiver 10 where the ground currents are converted to useful form.

[0044] FIG. 1 illustrates a first embodiment of the power receiver 10. The power receiver 10 comprises a resonant transformer 30 connected between an elevated terminal 15 and ground terminal 25. In this embodiment, the elevated terminal 15 is capacitively coupled to electric fields within the earth's ionosphere cavity and functions as an upper capacitive plate. A lower capacitive plate 20 is connected to the ground terminal 25 beneath the surface of the earth.

[0045] The resonant transformer 30 comprises a primary winding 35, secondary winding 40, ferromagnetic core 45, and capacitor 50. One end of the primary winding 35 is connected to the lower capacitive plate 20 and ground terminal 25. The opposite end of the primary winding 35 is connected via a spark gap 90 to the elevated terminal 15. The capacitor 50 is connected in parallel with the primary winding 35 of the resonant transformer 30 to form an LC circuit 55 with a resonance frequency range of between about 0.1 and 200 Hz. In a preferred embodiment, the resonant transformer has a Q of about 10 or greater and resonance frequency in the range of about 0.1-200 Hertz. For example, the resonant transformer 30 may have a resonance frequency of about 7.83 Hz, the fundamental Schumann resonance frequency. The secondary winding 40 of the resonant transformer 30 is connected to a power converter 110 as will be hereinafter described in greater detail. The power converter 110 converts the energy extracted from the earth's electric field by the power receiver 10 into a usable form for driving a load 140.

[0046] The elevated terminal/upper capacitive plate 15 comprises an insulated, dish-shaped plate with a large radius of curvature. The capacitance and resistance of the elevated terminal is chosen for receiving broadband electric field frequencies in the 0-200 Hz range. The upper capacitive plate 15 is sized to maximize to the extent practical coupling with the electric field in the earth's ionosphere cavity.

[0047] The lower capacitive plate 20 is also a dish-shaped plate with a large radius of curvature. One function of the lower capacitive plate 20 is to collect charge from the earth's ground currents and provide an instantaneous source of current as hereinafter described. The capacitance and resistance of the lower capacitive plate 20 is selected to promote the flow of current from the ground with minimal losses.

[0048] The spark gap 90 connected between the elevated terminal 15 and resonant transformer 30 comprises a pair of

electrodes **95**, **100** separated by an evacuated air gap **105**. Electrode **95** is connected to the upper capacitive plate **15**. Electrode **100** is connected to the resonant transformer **30**. The spark gap **105** prevents electrical discharge from the upper capacitive plate **15** to the earth's ionosphere cavity. The spark gap **90** in combination with the elevated terminal **15** function as an impulse generator that applies a high voltage impulse of about 10,000-40,000 volts to the primary winding **35** to initiate resonance in the transformer **30**.

[0049] In operation, the capacitive coupling of the upper capacitive plate **15** induces a high voltage operating current in the upper capacitive plate **15**. The upper capacitive plate is connected to a first electrode **95** to the spark gap **90**. When the voltage difference between the electrodes **95** and **100** reaches a threshold, a spark forms across the electrodes **95**, **100** and a high voltage impulse is applied to the primary winding **35** of the resonant transformer **30**. This high voltage impulse initiates resonance within the transformer **30**.

[0050] In resonant mode, the impedance of the resonance transformer is reduced to nearly zero allowing current to flow from the capacitive plate **20** and ground terminal **25** through the primary winding **35** of the transformer **30**, which in turn induces current in the secondary winding **40**. Power converter **110** converts the current flowing through the secondary winding **40** into a usable form for driving a load **140**. The transformer **30** will continue to resonate for a short period of time. By providing high voltage impulses to the primary winding **35** of the resonant transformer **30** at periodic intervals, it is possible to maintain a continuous flow of current from the earth into the resonant transformer **30**, thus producing a continuous supply of power.

[0051] FIG. 2 discloses a second embodiment of the primary receiver **10**. This embodiment includes a resonant transformer **30** connected between an elevated terminal **15** and ground terminal **25**. The resonant transformer **30** comprises a primary winding **35**, secondary winding **40**, ferromagnetic core **45** and a high voltage capacitor **50**. One end of the primary winding **35** is connected to the ground terminal **25**. The opposite end of the primary winding **35** is connected to the elevated terminal **15**. The capacitor **50** has a capacitance of about 0.01 micro-farads. In contrast to the previous embodiment, capacitor **50** is connected in series with the primary winding **35** and elevated terminal **15** and forms a LC circuit **55** with a Q of about 10 or greater and a resonance frequency in the range of about 0.1 to 200 Hz. In a preferred embodiment, the resonance frequency of the transformer **30** is 7.83 Hz, the fundamental Schumann resonance frequency. An impulse generator **60** is connected between the primary winding **35** of the resonant transformer **30** and the series capacitor **50** and applies a high voltage impulse to the primary winding **35** of the resonant transformer **30**. A battery **130** or other external power source supplies power to the impulse generator **60**. As previously described, the high voltage impulse applied by the impulse generator **60** initiates resonance within the resonant transformer **30** inducing current flow from the ground terminal **25** into the primary winding **35** of the resonant transformer **30**. The flow of current from the ground terminal **25** through the primary winding **35** induces current in the secondary winding **40**. Power converter **110** converts the electrical energy in the current flowing through the primary winding **40** into a usable form.

[0052] In contrast to the first embodiment, it is not required to capacitively couple the elevated terminal **15** in the second embodiment to the earth's ionosphere cavity. Rather, the

elevated terminal **15** in this embodiment provides lightning protection and dissipates some of the energy flowing into the power receiver **10** to the earth's ionosphere cavity. Also, in contrast to the first embodiment, the capacitor **50** is connected in series between the primary winding **35** of the transformer **30** and the elevated terminal **15**. Those skilled in the art will appreciate that the capacitor **50** could also be connected in parallel rather than series with the primary winding **35** as shown in FIG. 1. Another difference is that the impulse generator **60** has an external power source. The amount of energy generated by the power receiver **10**, however, is far greater than the energy needed to generate high voltage impulses. The first embodiment does not require an external power source to generate high voltage impulses.

[0053] FIG. 3 illustrates a third embodiment of the power receiver **10**. This embodiment is essentially the same as the embodiment shown in FIG. 2. The main difference is that a center tap of the primary winding **35** in the resonant transformer **30** is connected to an electrical ground **55**. It should be appreciated that the electrical ground **55** may be different than the earth ground. When the center tap of the resonant transformer **30** is grounded at a distance away from the ground terminal **25** (e.g. 50 ft to 100 ft), the power receiver **10** becomes a transmitter via the ground loop formed.

[0054] FIG. 4 illustrates the power receiver **10** of FIG. 2 in greater detail. The power receiver includes a resonant transformer **30** connected between a ground terminal **25** and an elevated terminal **15**. The resonant transformer **30** includes a primary winding **35**, secondary winding **40**, ferromagnetic core **45** and series capacitor **50** configured as previously described. The resonant transformer **30** may have a Q of about 10 and a resonance frequency in the range of about 0.1 to 200 Hz. The resonant transformer **30** may be made using an Allison transformer (part #1530BP120R) connected in series with a 0.01 micro-farad capacitor, such as the Condensor Products high voltage capacitor (part #TC 103-17-125). An impulse generator **60** is connected between the primary winding **35** of the resonant transformer **30** and the series capacitor **50** and applies a high voltage impulse in the range of about 10,000 to 40,000 volts to the primary winding of the transformer **30**. A battery **130** or other external power source supplies power to the impulse generator **60**. The power converter **110** connects to the secondary winding **40** of the resonant transformer **30** for converting current in the secondary winding of the transformer to a useful form.

[0055] The impulse generator **60** comprises a pulse generator **65** for generating low voltage pulses, a step-up transformer **80** for converting the low voltage pulses from the pulse generator **65** to high voltage pulses, and a spark gap **90** for generating sparks responsive to the high voltage pulses from the step-up transformer **80**.

[0056] The pulse generator **65** comprises a square wave generator **70** and solid state relay **75**. The square wave generator **70** generates a digital pulse stream. In one embodiment, the digital pulse stream generates a square waveform with a frequency of about 7.83 Hz. The frequency of the digital pulse stream is selected to match the resonance frequency of the transformer **30**, though such is not necessarily required. The pulse stream output from the square wave generator **70** is applied to the solid state relay **75**. The solid state relay **75** is connected between a battery or other power source and a first winding of the step-up transformer **80**. The solid state relay **75** functions as a switch that is activated responsive to the waveform from the square wave generator **70** to provide

a continuous stream of low voltage pulses from the battery to the first winding of the step-up transformer **80**. A 1 ohm resistor is connected between the solid state relay **75** and step-up transformer **80**.

[0057] The step-up transformer **80** converts the low voltage pulses from the pulse generator **65** to high voltage pulses that are applied to the spark gap **90**. The step-up transformer has a 0.5 micro-farad capacitor connected in parallel with the primary winding of the step-up transformer **80**. The step-up transformer produces pulses at the output of about 30,000 to 40,000 volts.

[0058] The spark gap **90** comprises a pair of electrodes **95**, **100** separated by an air gap **105**. As previously described, when the voltage potential between the electrodes **95**, **100** reaches a threshold, a spark forms between the electrodes **95**, **100** and supplies a nearly instantaneous, high voltage impulse to the primary winding **35** of the resonant transformer **30**. This high voltage impulse initiates resonance in the resonant transformer **30** inducing current flow from the ground terminal **25** through the primary winding **35** of the resonant transformer **30**.

[0059] The power converter **110** comprises a bridge rectifier **115**, filter capacitor **120**, charge controller **125**, and inverter **135**. The bridge rectifier **115** converts the AC current flowing through the secondary winding **40** of the resonant transformer to a DC current. a Filter capacitor **120** removes unwanted frequencies from the DC current. The filter capacitor **120** has a capacitance of about 1000 micro-farads. The DC current is input to the charge controller **125**. The charge controller **125** may, for example, comprise a maximum power point tracking (MPPT) charge controller, which is commonly used in solar power generating systems. The charge controller **125** applies a small amount of energy to a battery **30** to charge the battery **130**. As previously noted, the battery **130** serves as a power source for the impulse generator **60**. The remaining current is supplied to an inverter **135**, which converts the DC current to an AC current with a desired voltage and frequency, e.g., 120 volts/60 Hz AC. The power converter **110** as shown in FIG. 4 may be utilized in the embodiment shown in FIGS. 1, 2 and 3.

[0060] FIG. 5 illustrates a power converter **10** according to another embodiment. The power converter **10** comprises a plurality of resonant transformers **30** connected between a ground terminal **25** and elevated terminal **15**. Each of the resonant transformers **30** comprises a primary winding **35**, secondary winding **40**, ferromagnetic core **45** and series capacitor **50**. The primary windings **35** of the resonant transformers **30** are connected in parallel. The secondary windings **40** are connected in series with the power converter **110**. An impulse generator **60** applies a high voltage impulse to the primary windings **35** of the resonant transformers **30**. A battery **130** or other external power source supplies power to the impulse generator **60**. The power converter **110** converts the current in the power converter circuit to a usable form for driving a load **140**.

[0061] In one embodiment, each of the resonant transformers **30** shown in FIG. 5 is configured to have a different resonant frequency. In one embodiment, the resonant transformers **30** are configured to resonate at frequencies of 7.83 Hz, 14.8 Hz, 20.3 Hz and 26.8 Hz respectively. Additional resonant transformers **30** could be added to operate at other resonance frequencies.

[0062] FIGS. 6A-6C illustrate a high quality ground antenna array **200** which may be used as a ground terminal **25**.

The ground antenna array **200** comprises a generally cylindrical ground shaft **205** disposed with a hollow cylinder **220** and a plurality of reinforced, heavy gauge ground wires **210** attached at one end to the ground shaft **205**. The ground shaft **205** and ground wires **210** should be highly conductive and have low resistance to supply current from the ground to the power receiver **10**. In one embodiment, the ground wires **210** may be copper or other highly-conductive metal. The end of the ground shaft may be pointed to facilitate insertion into the earth. A connection port on the ground shaft **220** is provided to electrically connect the ground antenna array **220** to the resonant transformer **30**.

[0063] The hollow cylinder **220** has external threads **25** to facilitate insertion into the ground. A rotator nut **235** is fixedly secured to the top end of the hollow shaft **220**. A square shaft **215** protrudes from the top end of the ground shaft **205** into the opening in the rotator nut **235**. FIG. 6B. A tool **250**, shown in FIG. 7, engages with the rotator nut **235** and square shaft **215** during insertion of the ground antennas array **200** into the ground as will be hereinafter described.

[0064] The insertion tool **250** is shown in FIG. 7. The insertion tool **250** includes a tool body **255** having a first socket **260** on one side to fit the rotator nut **235** on the hollow cylinder **220** and a second socket **265** on the other side to fit the square shaft **215** on the ground shaft **205**. Arms **270** extend from the outer periphery of the tool body **255** for manually or mechanically turning the insertion tool **250**.

[0065] Before the antenna array **200** is deployed, the ground wires **210** are wound around the ground shaft **205** with the free ends protruding slightly from respective openings **230** in the hollow cylinder **220** to a distance not to exceed one half ($\frac{1}{2}$) the depth of the external threads **225** on the hollow cylinder **220**. FIG. 6B illustrates the ground antenna array **200** before deployment. FIG. 6C illustrates the ground antenna array in a deployed configuration.

[0066] Installation of the ground antenna array **200** is performed in two stages. In the first stage, a hole slightly smaller in diameter than the threads **235** of the hollow cylinder **220** is drilled into the Earth to a depth matching the length of the hollow cylinder **220** or slightly longer. The hole is filled with water and the water is allowed to soak into the soil. After the ground is softened, the hollow cylinder **220** is rotated using the insertion tool **250** to insert the ground antenna array **200** into the ground. The first socket **260** of the insertion tool **250** is engaged with the rotator nut **230** and the insertion tool **250** is turned by hand or a mechanized rotating shaft fitted and attached to the tool arms **270** to thread the ground assembly into the hole. During the initial insertion of the ground antenna array **200**, the ground shaft **205** is fixed to the hollow shaft **220** and rotates with the hollow shaft. The hollow cylinder **220** is rotated until it reaches the full depth of the hole.

[0067] Once the ground antenna array **200** has been fully inserted into the earth, the insertion tool **250** is flipped over and the second socket **265** of the insertion tool **250** is engaged with the square shaft **215**. The insertion tool **250** is turned by hand or a mechanized rotating shaft fitted and attached to the tool arms **270** to rotate the ground shaft **205**. During the second phase, the ground shaft **205** rotates freely inside the hollow cylinder **220**. Rotation of the ground shaft **205** causes the reinforced ground wires **210** to extend radially into the earth. The ground shaft **220** is rotated until the ground wires are fully extended. The ends of the ground wires may be sharpened to aid in the extension of the ground wires during the second phase.

[0068] After the ground antenna array 200 is deployed, a connection cable 280 is attached to a connection port 240 on the ground shaft 220 to electrically connect the ground antenna array 220 to the resonant transformer 30 in the power receiver 10.

What is claimed is:

1. A power receiver for extracting electrical energy from the earth's electric field, said power receiver comprising:

- a resonant transformer connected to a ground terminal disposed below the surface of the earth;
- an impulse generator for generating and applying a high voltage electrical impulse to a primary winding of the resonant transformer to induce current flow from the ground terminal through the primary winding of the transformer; and
- a power conversion circuit connected to a secondary winding of the resonant transformer to convert electrical current flowing through the secondary winding to a desired form.

2. The power receiver of claim 1 wherein a resonant frequency of the resonant transformers is below 200 Hz.

3. The power receiver of claim 1 wherein the resonant transformer comprises a ferro-resonant transformer.

4. The power receiver of claim 1 further comprising an elevated terminal, and wherein the primary winding of the resonant transformer is connected between the ground terminal and elevated terminal.

5. The power receiver of claim 4 wherein the elevated terminal comprises an upper capacitive plate coupled to the earth's ionosphere cavity.

6. The power receiver of claim 5 wherein the impulse generator comprises:

- the upper capacitive plate;
- a pair of electrodes separated by a spark gap, said electrodes connected between the upper capacitive plate and the primary winding of the resonant transformer and configured to generate a spark when a voltage difference between the electrodes reaches a predetermined level.

7. The power receiver of claim 1 wherein the impulse generator comprises:

- a pulse generator for generating low voltage pulses;
- a step-up transformer for converting the low voltage pulses provided by the pulse generator to high voltage impulses;
- a spark gap connected between the step-up transformer and the primary winding of the resonant transformer to generate a spark responsive to the high voltage impulses from the step-up transformer.

8. The power receiver of claim 1 wherein the impulse generator comprises:

- a pulse generator for generating low voltage pulses;
- a step-up transformer connected to the primary winding of the resonant transformer for converting the low voltage pulses provided by the pulse generator to high voltage impulses.

9. The power receiver of claim 1 wherein the impulse generator comprises a solid state spark generator.

10. The power receiver of claim 1 wherein said resonant transformer includes a capacitor connected in parallel with the primary winding.

11. The power receiver of claim 1 wherein said resonant transformer includes a capacitor connected in series with the primary winding between the impulse generator and the elevated terminal.

12. The power receiver of claim 1 wherein comprise multiple resonant transformers having primary windings connected in parallel between the ground terminal and the elevated terminal.

13. The power receiver of claim 12 wherein the resonant transformers have different resonant frequencies.

14. The power receiver of claim 13 wherein the resonant frequencies of the resonant transformers are all below 200 Hz.

15. The power receiver of claim 12 wherein the resonant frequencies of the resonant transformers are matched to respective Schumann resonances.

16. A power receiver for extracting electrical energy from the earth's electric field, said power receiver comprising:

- a resonant circuit connected to a ground terminal disposed below the surface of the earth, said resonant circuit having a resonant frequency below 200 Hertz
- an impulse generator for generating and applying a high voltage electrical impulse to the resonant circuit to induce current flow from the ground terminal through the resonant circuit; and

- a power conversion circuit connected to the resonant circuit to convert electrical current flowing through the resonant circuit to a desired form.

17. The power receiver of claim 16 wherein the impulse generator comprises:

- a pulse generator for generating low voltage pulses;
- a step-up transformer for converting the low voltage pulses provided by the pulse generator to high voltage impulses;
- a spark gap connected between the step-up transformer and resonant circuit to generate a spark responsive to the high voltage impulses from the step-up transformer.

18. The power receiver of claim 16 wherein the impulse generator comprises:

- a pulse generator for generating low voltage pulses;
- a step-up transformer connected to the resonant circuit for converting the low voltage pulses provided by the pulse generator to high voltage impulses.

19. The power receiver of claim 16 wherein the resonant circuit comprises a resonant transformer having a primary winding, a secondary winding, and resonant capacitor connected in parallel with the primary winding.

20. The power receiver of claim 16 wherein the resonant circuit comprises a resonant transformer having a primary winding, a secondary winding, and resonant capacitor connected in series with the primary winding.

21. The power receiver of claim 16 wherein the resonant circuit comprises multiple resonant transformers having primary windings connected in parallel to the ground terminal.

22. The power receiver of claim 21 wherein the resonant transformers have different resonant frequencies.

23. The power receiver of claim 22 wherein the resonant frequencies of the resonant transformers are all below 200 Hz.

24. The power receiver of claim 23 wherein the resonant frequencies of the resonant transformers are matched to respective Schumann resonances.

25. A ground terminal for a power receiver, said ground terminal comprising:

- a ground shaft configured for insertion beneath the surface of the earth;
- a hollow cylinder surrounding the ground shaft and having a plurality of openings; and

a plurality of ground wires connected at one end to the ground shaft said ground wires being wound around the ground shaft and having free ends protruding through respective openings in the hollow shaft r so that rotation of the ground shaft relative to the hollow cylinder causes the ground wires to extend radially into the earth.

26. A method of extracting power from the earth, said method comprising:

applying a high voltage impulse to resonant circuit coupled to a ground terminal disposed beneath the surface of the earth to initiate resonance in the resonant circuit and induce the flow of current from the ground terminal to the resonant circuit; and

converting the current flowing from the ground terminal into the resonant circuit into a useful form.

27. The method of claim **26** wherein resonant circuit comprises a resonant transformer including a primary winding coupled to the ground terminal and a second winding couple to a power converter, and wherein applying a high voltage impulse to resonant circuit comprises applying a high voltage impulse to the primary winding of the resonant transformer.

28. The method of claim **27** wherein applying a high voltage impulse to the primary winding of the resonant transformer comprises applying an impulse in the range to 10,000 to 40,000 volts to primary winding of the transformer.

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